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How are snowmelt rates changing across climates? Insights from a new Northern Hemisphere SWE dataset

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Although warming temperatures should intuitively lead to faster snowmelt, some studies suggest that melt rates might be slower in a warming world. This assumes that typically deep snowpacks are thinning and become isothermal earlier in the season when less solar radiation is available for melt. Investigating these changing snow dynamics is challenged by a lack of observations on water content of the snowpack, the Snow Water Equivalent (SWE). However, high quality observations of snow depth are generally more available in both space and time, even at higher elevations. Here we present a new dataset of historical SWE time series over the Northern Hemisphere, including a wide variety of climates. These time series are obtained converting historical ground-based snow depth time series to SWE by using the DeltaSNOW model. For the conversion to work over a range of climates, we apply a regional calibration of model parameters based on climatological data and provide model performance and uncertainty estimates. For >2.000 sites characterised by seasonal snow, we investigate changes in total snow accumulation, timing of snowmelt and melt rates for the period 1980-2020. Large decreases in total melt and earlier melt timing are widely observed. However, trends in snowmelt rates are generally weak and spatially inhomogeneous. Slower snowmelt in a warmer world occurs mostly on deep snowpacks that have been heavily depleted and where the number of days with melt has not significantly changed, making melt rates slower. However, both faster and slower melt are observed on sites where both the amount of melt and number of melt days have decreased. We provide an analysis of the causes for the spatial and temporal variability in trends. We find that trends can differ depending on the definition of melt rate and peak SWE, and that the drivers of the trends differ over different climates. Strong warming generates large melt events during the late accumulation season, challenging the commonly used definition of peak SWE and making it harder to compare the snowmelt dynamics of the past and the current climate. We note that focusing on melt rate change might mask important effects on melt timing and magnitude, because a proportional reduction in total melt and number of melt days can lead to no change in melt rate.